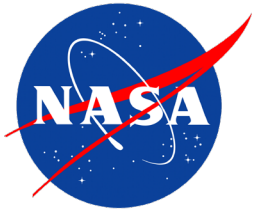
Instantiating R&M in the Digital Engineering Eco System







Monday, January 25th, 10:15 – 12:15am

Anthony John DiVenti Jr.

NASA Office of Safety & Mission Assurance (OSMA)



The 69th Annual Reliability & Maintainability Symposium

Overview and Outline

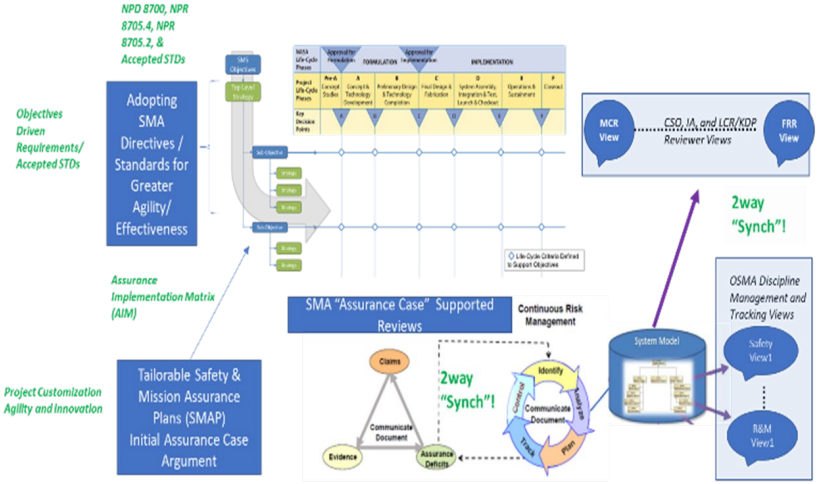
- **Recap from last year's (2023) presentations: Key Take-Aways**
 - SMA's Digital Engineering Future Paper
 - R&M as the Part of the Digital Engineering Eco-System

- **Current Focus - 6 Major Areas**
 1) Merge OSMA's and OCE's Digital Strategy Roadmaps in a Shared "Capabilities Development" Implementation Plan
 2) Cross NPR Modeling and OSMA Policy-Enabled Objectives-Driven Planning Framework modeling
 3) SMA Discipline (including R&M) STDs and Model-Based Data Requirement Descriptions (DRDs)/Data Item Descriptions (DIDs)
 4) Document Structuring Norms (i.e., NPRs/STDs/DATA as part of metamodeling structure)
 5) Tying all together in SMA / R&M related Application examples
 6) Training, Guidance and Personnel Development

- **Future**

Recap of SMA's Digital Future Paper Presentation RAMS 2023

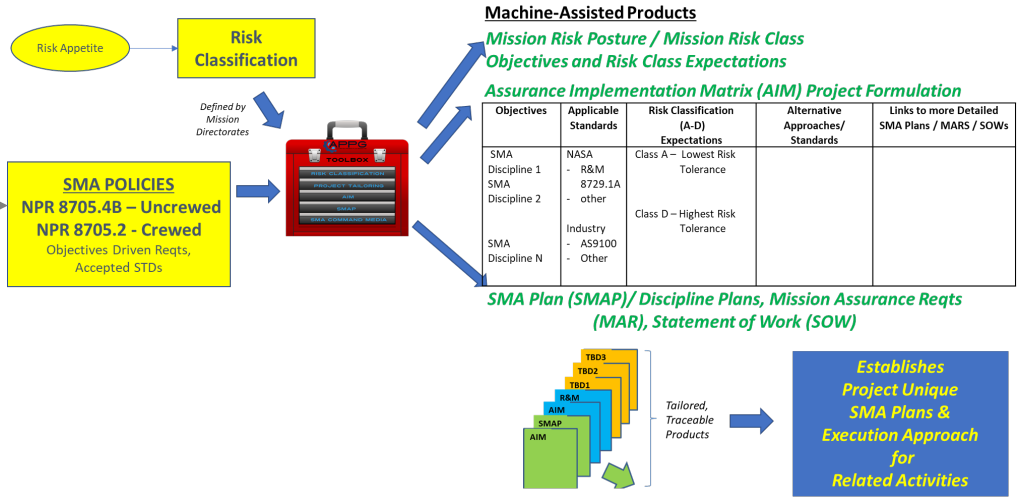
(1) Digital SMA / R&M Framework



(2) Key Digital Building Blocks

#	Key Building Blocks	Summary	Examples
1	Policy Enabled Objectives Hierarchy	Methodology for Organizing Objectives in a 'tree structure' enabling traceability, clarity about customization and completeness	NASA STD 8729.1A
2	Objective-Driven Requirements	Requirements are established based on, and directly traceable to, corresponding objectives. The requirements, and "shall" statements are necessary for performing work.	NPR 8705.4B
3	Accepted Standards	Numerous standards exist across industries, government agencies and standards organizations. The ability to determine which are acceptable in what context is key to tailoring	AS9100
4	Assurance (Safety) Case	A structured arument supported by evidence. An Assurance Case framework enables, planning, execution and evaluation of a wide variety of "cases" that certain objectives will be met over time (non-static). Enables clarity about goals and metrics.	Offshore Oil & Gas, Defense, Medical, Transportation, Nuclear (Cullen 1990)
5	Interoperability	Various tools, workflows, and data streams must seamlessly work together to achieve the Digital Transformation gains in speed and accuracy. This means less focus on tools and more focus on interfaces between them	UML, UPDM, SysML
6	Ontology / Ontological Framework	Domain represenation, Data/Process Models, Structured Data, Specifications, etc.	ISO/IEC 21838-2:2021
7	FAIR/FAIRUST Principles	Embodies the idea that Data must Findable, Accesible, Interoperable, Reuseable, Understandable, Secure and Trusted	FAIR Guiding Principles for scientific data management and stewardship (2016)

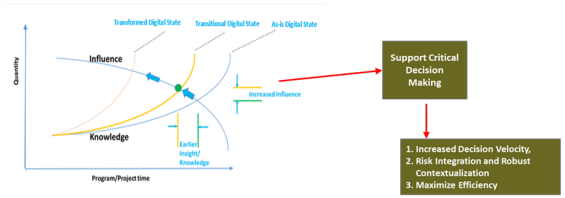
(3) Early Wins – Automated Project Plan Generator (APPG)



REFERENCE: DiVenti, Rainbolt, Cornford, Forsbacka, and Feather; *"NASA's Safety, Reliability, and Mission Assurance Digital Future"*, RAMS USA (2023)

Recap of "R&M as part of the Digital Engineering Ecosystem"

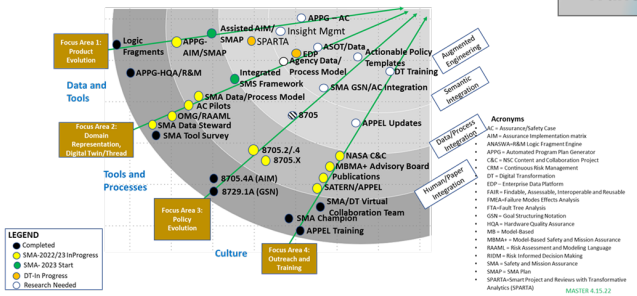
(1) Strategic Roadmaps – translating into Organizational Plans



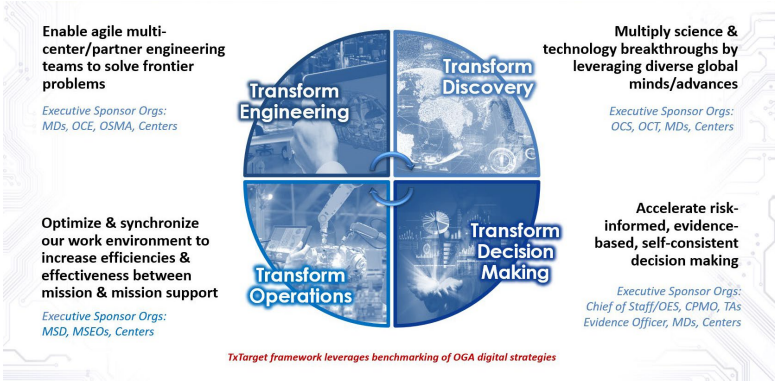
"Decrease GAPs in the delivery of SMA related information in support of Decision – Making

Utilization of Model-Based and Assurance Case Frameworks

Transform



(2) "Digital Eco-System" Perspective – not just SMA or MBSE



(3) Look for Opportunities of "Shared Interest"

NOT MEASUREMENT SENSITIVE

NASA TECHNICAL HANDBOOK

NASA-HDBK-1004

Office of the NASA Chief Engineer

Approved: 2020-04-01
Superseding NASA-HDBK-0008

NASA DIGITAL ENGINEERING ACQUISITION FRAMEWORK HANDBOOK

REFERENCE: DiVenti; *"R&M as part of the Digital Engineering Eco-System"*, RAMS Advisory Board Presentation (2023)

Since then, ……Current Focus and Activities

1

- Merge OSMA's and OCE's Digital Strategy Roadmaps into a Shared "Capabilities Development" Implementation Plan

2

- Cross-NPR Modeling
- OSMA Policy Enabled Objective-Driven Planning Framework Modeling
- Hierarchical Model Decomposition and Traceability

#	Key Building Blocks	Summary	Examples
1	Policy Enabled Objectives Hierarchy	Methodology for Organizing Objectives in a 'tree structure' enabling traceability, clarity about customization and completeness	NASA STD 8729.1A
2	Objective-Driven Requirements	Requirements are established based on, and directly traceable to, corresponding objectives. The requirements, and "shall" statements are necessary for performing work.	NPR 8705.4B
3	Accepted Standards	Numerous standards exist across industries, government agencies and standards organizations. The ability to determine which are acceptable in what context is key to tailoring	AS9100
4	Assurance (Safety) Case	A structured arument supported by evidence. An Assurance Case framework enables, planning, execution and evaluation of a wide variety of "cases" that certain objectives will be met over time (non-static). Enables clarity about goals and metrics.	Offshore Oil & Gas, Defense, Medical, Transportation, Nuclear (Cullen 1990)
5	Interoperability	Various tools, workflows, and data streams must seamlessly work together to achieve the Digital Transformation gains in speed and accuracy. This means less focus on tools and more focus on interfaces between them	UML, UPDM, SysML
6	Ontology / Ontological Framework	Domain represenation, Data/Process Models, Structured Data, Specifications, etc.	ISO/IEC 21838-2:2021
7	FAIR/FAIRUST Principles	Embodies the idea that Data must Findable, Accesible, Interoperable, Reuseable, Understandable, Secure and Trusted	FAIR Guiding Principles for scientific data management and stewardship (2016)

3

- SMA Discipline STDs/ MB DRDs/DID
- NASA STD 1004 / 1009
- Define required Data and when it is needed (Plan, Design, I&T, etc.)

4

- Document Structuring Norms
- Tie NPRs/STDs/DATA to a metamodeling structure

5

Tying all together in SMA / R&M related Application examples

6

Training, Guidance, and Personnel Development

Initially show High level Objectives to Requirements to STDs to Applicable DRDs/DID

Since then, ……Current Focus and Activities

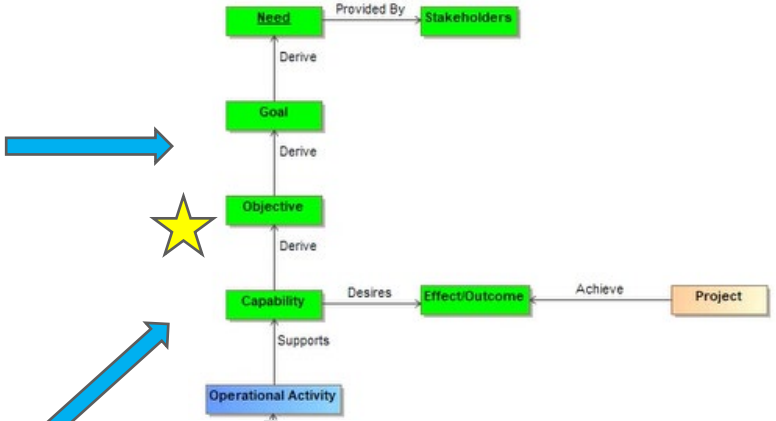
1

- Merge OCE AND OSMA Roadmaps into a Shared "Capabilities Development" Implementation Plans

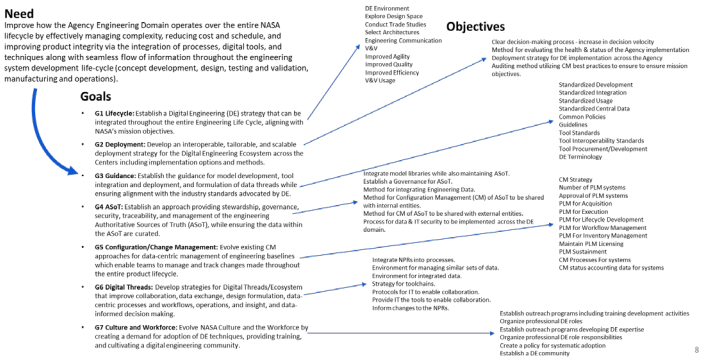
★ *Using Magic Draw with a UAF Objectives-to-Capability Mapping profile to **digitally integrate** Digital Engineering (DE) and DigitalSMA plans*

OSMA's Digital Strategy / Plan

Objective # (=Eng Goal Level)	Intended Results (=Eng. Objectives)	Capabilities (=Eng. and OCIO Capabilities):	Specific Activities/Projects (Note: UAF Projects include Activities, Resources, Personnel, and Enablers)	Time Scale: FY24; Beyond FY24
OBJECTIVE 3 - Enable implementation of SMA Policy	OSMA policies (rules) are lean, objectives-driven, and consistently applied	Objective-Driven, Risk-Informed, and Case-Assured, Policy Framework	Complete Top-Level SMA Discipline Objectives accross NPR 8705.2B and NPR 8705.4B	FY24
			Complete Top-Level SMA Discipline Objectives accross NPR 8705.4C.	Beyond FY24
	Strengthen OSMA products (Tools, Training, Consulting) to enable effective implementation of lean, objectives-driven policies		Complete Top-Level SMA Discipline Objectives accross other roadmap NPRs.	Beyond FY24
	OSMA has sufficient expertise and capabilities to influence risk-informed implementation of policy within acceptable risk posture	Machine-Assited planning/SOW/DRDs development and activity progress tracking platform (e.g., APPG) consistent with NPR 8705.4, NPR 8705.2, SMS Assurance STD, and P/p needs over mission development.	Complete APPG MVP Release consistent with 8705.4B.	FY24
			Complete APPG MVP Release consistent with 8705.2A.	Beyond FY24
		Training accompanying Policy and Machine-Assisted Planning roll-out, including visual aides(examples) of a completed AIM, SMA Plan, Discipline plan(s) at difference life cycle phases	Complete initial 8705.4 and APPGTraining (Tie to policy releases)	FY24
			Complete initial 8705.2 (Crewed) and APPG Training	Beyond FY24
			Complete training for other Roadmap NPRs	Beyond FY24
		Deliverable/Evidence (Data) to Objectives-Trace **(i.e., Reference Assurance Cases, MB DRD/DID/STD)** for each SMA Discipline area (by life cycle) and for Cross-SMA Discipline Objectives	Incremental tracing mapping tied to STDs updates accross all SMA Discipines, tied to MB DRD/DID/STDs)	Beyond FY24



OCE's DE's NGO Strategy / Plan



Developing a "Shared" Engineering & SMA Capabilities List

The main purpose of this review is to assess the completeness and correctness of the capabilities traced to DE enterprise objectives.

Capabilities are defined as:
"An enterprise's ability to achieve a desired effect realized through a combination of ways and means along with specified measures."

In relation to objectives, capabilities should answer the question:
"What capabilities are necessary to accomplish the objective"

Some development is shown in the operational layer as aspects of the capabilities were determined to be better represented as operational activities.

Since then, ……Current Focus and Activities

2

- Cross-NPR Modeling
- OSMA Policy Enabled Objective-Driven Planning Framework Modeling
- **Hierarchical Model Decomposition and Traceability**

Procedural Requirements, General **Roles**, General **Products**, **Life Cycle Elements** explicitly modeled, Specific Role, Responsibility, Relationship structures [7123.1, 7120.5, 8705.x]

Detailed OSMA Policy Workflow i.e., NPR 8705.4B), **Objectives-driven SMA Requirements,** Discipline-specific **Objectives, Expectations, Accepted STDs,** and **SMA/ R&M Analysis Products vs Life Cycle Gates**

Actionable plans and products (e.g., R&M) tailored and customized; remains consistent with 8705.4 above and referenced STDs.

Cross NPR Modeling

OSMA Policy Modeling (e.g., 8705.4)

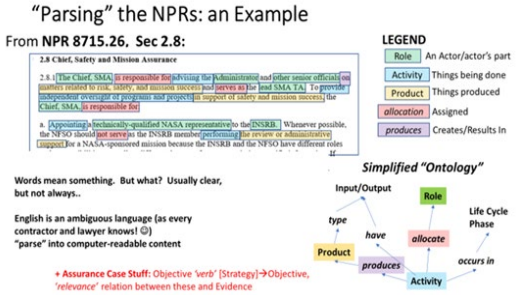
Detailed Lifecycle Implementation plans and Requirements (e.g. SMAP, R&M Plan, QA Plan, required Analysis)

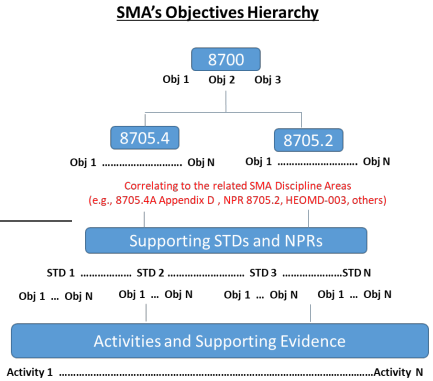
Cross NPR Model elements enable customization and synchronization

ALL aspects of SMA Planning products traceable to guiding Policies

Cross SMA Model elements enable customization and implementation in plans

ALL Plan and required analysis product elements traceable back to 8705 Objectives and Expectations





Decomposition/ Inheritance

Traceability/ Contextualizing

Since then, …… Current Focus and Activities

3

- SMA Discipline STDs/ MB DRDs/DID
- NASA STD 1004 / 1009
- Define required Data and when it is needed (Plan, Design, I&T, etc.)

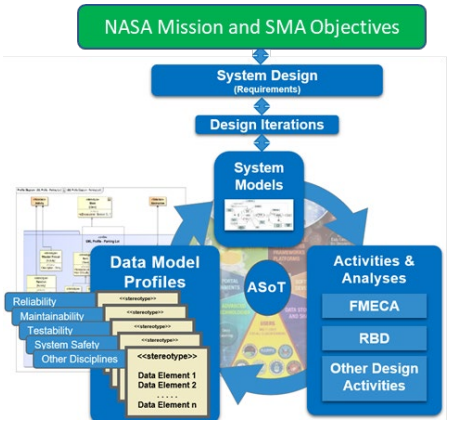


Image source: DeLuca, Chris. Advancing the State of R&M Engineering Practice. NDIA Systems and Mission Engineering Conference. December 2021. Orlando, FL.

NASA DIGITAL ENGINEERING ACQUISITION FRAMEWORK HANDBOOK

NASA-HDBK-1004

APPENDIX A

DATA REQUIREMENTS DESCRIPTIONS (DRDs)

A.1 PURPOSE

This Appendix provides recommended example DRDs for supporting digital and model-based acquisitions are as follows:

- DRD Purpose and Instructions. (Refer to A.2.)
- Technical Data Package (TDP). (Refer to A.3.)
- Engineering Model-based x (MBx) Models and Associated Data. (Refer to A.4.)
- Configuration and Data Management Process Audit (CMPA) (Refer to A.5.)
- Configuration and Data Management Plan (CDMP) (Refer to A.6.)
- Configuration Status Accounting (CSA) (Refer to A.7.)
- Specification and Drawing Trees (SDT) (Refer to A.8.)
- Engineering Models, Drawings, and Associated Lists (EMDAL) (Refer to A.9.)
- Change Request (CR) (Refer to A.10.)
- Functional Configuration Audit/Physical Configuration Audit Documentation (AD) (Refer to A.11.)
- Requirements Exchange Format (REF) (Refer to A.12.)
- Master Records Index (MRI) (Refer to A.13.)
- Contract Language for Data Acquisition and Interoperability (Refer to A.14.)
- Recommended Configuration Management (CM) Statement of Work Section for Contractors (Refer to A.15.)

NASA OSMA *working to leverage NASA-HDBK-1004 to add* ***NEW*** *SMA / R&M related DRDs/ DIDs*

Initial DRD/DID Targets

(1) Supply Chain Visibility (SCV) Data Requirements Description (DRD)

(2) OUSD MB FMECA/FMEA DRD

Since then, ……Current Focus and Activities

4

- Document Structuring Norms
- Tie NPRs/STDs/DATA to a metamodeling structure

Considerations for developing Metamodeling Structures and guidance beyond Model-Based DRDs/DIDs (e.g., SE Model extensions and data):

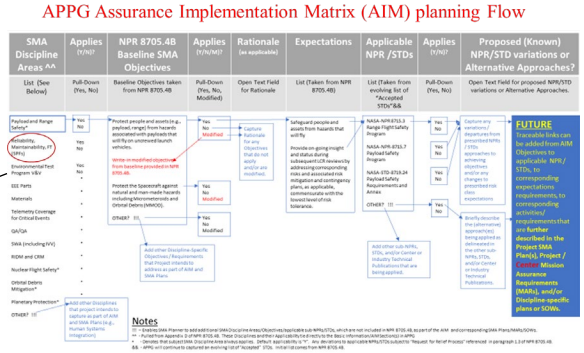
- Selecting a common data structuring format addressing:
 - Baseline / basic “Machine-Readable” formats
 - Establish accepted “Document to Machine-Readable” format conversion protocols (e.g., Python Script Libraries, Accepted PDF Conversion Tools)
 - Primary “Machine-Readable” formats (e.g., JSON, XML).
 - Enables “Triple Store” relationships (i.e., Subject -> Predicate -> Object)
- Clear Naming Conventions (e.g., SysML Extensions to R&M, OMG RAAML))
- Consistent Data Formats (e.g., dates, times, Ps, MTBF)
- Hierarchical Structures (e.g., leverage Goal Structuring Notation (GSN), Safety or Assurance Case frameworks)
- Schema Definitions (e.g., Ps estimates, Life Estimates, Reliability Growth, Criticality Analysis,
- Semantic Tagging / Ontological Based Reasoning

Since then, ……Current Focus and Activities

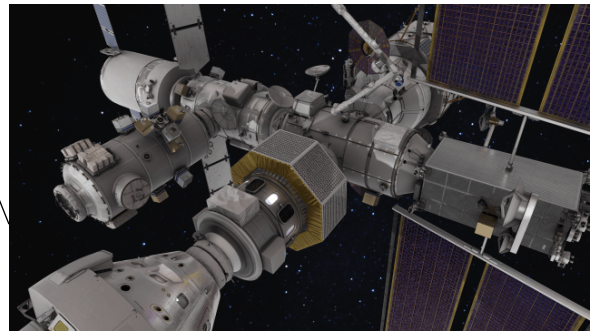
5 Tying all together in S&MA/R&M related Application examples

Targeted R&M application examples include:

- Automated Project Plan Generator (APPG), machine-assisted, SMA & R&M Planning and acquisition requirements development support.



- Gateway Logistics Planning integration with SCV DRD and NASA's Supply Chain Insight Central Data Platform



- OUSD MB FMECA DRD applied to a contract (i.e., DI-SESS-82426) - Need a Willing Project ☺

- NASA Failure Modes/ Mechanisms Reference Libraries



Since then, ……Current Focus and Activities

6 Training, Guidance, and Personnel Development

In Formulation / Under development:

- Digital Engineering Familiarization
- Introduction to Objectives Hierarchical Planning and Development, 8705.4/8729 Training, 8705.2 Training
- Determination of Required Training and Development: Modification of Existing Training requirements

Areas/Potential examples include:

- APPG infused with Objectives-Driven, Risk-Informed, and Case-Assured planning guidance. Guidance will enable users to apply “Objectives-Driven” planning on actual projects
- Trilateral Space Agency participation on development of a Model-Based Mission Assurance Application – initial focus on MB FMECA/FMEA application
- Benchmark / leverage DAU Activities to greatest extent possible.
- Utilize Structured Data norms and best practices

- **Looking for examples, opportunities to leverage**

Future

- Barriers / Risks
 - This is a big effort. Requires Decomposition/Modularity, Iteration, Patience and Funding
 - Leveraging has pros and cons….
 - Resistance to change (general), Resistance to change (from the losers)…
 - Tool interchanges, favorite tools
- Next Steps
 - Continue incremental development in alignment with Strategic Roadmap(s) / Plans, updated regularly based on technology advancements, emerging opportunities, etc.
 - Continually explore Shared-Interests/Opportunities – Please contact Tony DiVenti (Anthony.j.diventi@NASA.gov) to participate and share.
 - Leverage!!!!!

Thank you for the opportunity!
Any Questions?

Back-up